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TABLE OF PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS.(U)
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AUTHOR

MARINE SCIENCES DEPARTMENT

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U. S. NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D. C. 20390

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TABLE OF PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

This table of proposed oceanographic measurement requirements has been compiled from statements prepared and reviewed by several individuals within the Marine Sciences Department. These requirements are not absolute nor static. They reflect the judgement of many people and will change to meet the evolving oceanographic needs of the Navy.

This table is being published as an Informal Manuscript Report for broad distribution within the Marine Sciences Department. Exceptions taken to the specifications and statements contained herein should be made a matter of record by memorandum to the Director, Marine Sciences Department via Division Directors and Branch Heads in order that they can be considered during periodic revisions.

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

A. WATER MOTION

VARIABLES	MEASUREMENT		SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
	RANGE	ACCURACY		
1. Currents				
a. Present capabilities			1 min average (or greater) at intervals of 1 min to 1 hour. Recorded digitally and directly unattended. Sampling duration is a function of sampling interval and power supply - from 1 week to 3 months.	Instruments are limited to 6,000 meters depth. Current direction accuracy is a function of magnetic latitude. Speed accuracy is based on Savonius Rotor limitations.
(1) Speed	2.6 to 260 cm/sec	2.6 cm/sec ±100% 5.2 cm/sec ± 50% ≧ 25.8 cm/sec ± 5%		
(2) Direction	001° to 360° Mag	± 10° Relative		
b. Required capabilities			Sampling rate variable from continuous to hourly increments. Analog and/or digital recording with short period (≧1 min) averages.	Depending upon requirements, self contained, shipboard suspended, or telemetered on request to aircraft, ship, or satellites. Indication of meter malfunction is required. Operating depth from surface to 6,000 meters with limited capability to 8,000 meters. Low speed, fast response components required to study turbulence.
(1) Speed	0.26 to 310 cm/sec	0.26 cm/sec ± 100% 2.6 cm/sec ± 50% ≧ 5.2 cm/sec ± 5%		
(2) Direction	001° to 360° True	±2° Resolution		
2. Waves				
a. Present capabilities			Continuous record. Sampling interval is 1 sec. Minimum duration required for analysis is 15 minutes.	Equipment used extensively as "open-ocean wave standard" in tests of new instrumentation and new forecast theories. Time interval is 2 to 25 seconds between crests.
(1) Resistance wire wave staff (a) Height	0 to 16 meters	± 15 cm		
(2) Shipboard wave meter (a) Height	0 to 12 meters	5% of full scale	Continuous record. Sampling interval is 1 sec. Minimum duration required for analysis is 15 minutes.	Field tests in deep water show good to fair agreement against resistance wire wave staff. Tests are continuing. Intentions are to use it as part of synoptic network.
(3) Airborne wave meter Emertron (a) Height	0.5 to 15 meters	± 15 cm to ± 10%	Continuous record, minimum duration of 4 min. Sampling interval is 0.1 sec or 10 meters at an aircraft speed of 100 m/sec	Recording altitude is 50 meters. Comparisons with resistance wire wave staff at Argus Island show good agreement on upwind flights; fair agreement on downwind flights. Hazeltine data are not yet analyzed.
Hazeltine (a) Height	0.5 to 15 meters	± 15 cm		
(4) Sonic surface scanner (a) Height	0 to 12 meters	± 15 cm	Continuous record. Sampling interval is 0.7 sec.	Equipment is inverted echo sounder. Measures height of wave from deck of submarine. Allows for maneuverability to submerge and record in regions of high wave generation. Needs correction for ship motion. EDO has been used with some success; narrower beam is better.
(5) Telemetering wave buoy (a) Height	0 to 6 meters	Marginal	Continuous record. Sampling interval is 1 sec.	Marginal accuracy because of low cost design. Best used for full scale sea trials and ship design.
(6) Floating wave staff (a) Height	0 to 6 meters	Marginal	20 min continuous record. Sampling interval is 1 sec.	Not used very often because of marginal accuracy limitations and difficult handling problems.
b. Required capabilities			Record length of 1 min per each 2 km/hr of average wind speed with minimum record of 15 minutes. Sampling interval of ½ sec. (Surface observations only). One to three year record per location.	Detailed studies of wave profile desired for sound scattering studies. Relative accuracy of direction should be ± 2° for directional spectrum.
(1) Height	Changes in water level over a range of 20 meters recorded against time or distance	± 2½% actual readings.		
(2) Period		± 3% for time interval between crests ($1 < \bar{T} < 30$ sec)		
(3) Direction	001° to 360°	± 10° True		

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

A. WATER MOTION (CONT'D)

VARIABLES	MEASUREMENT		SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
	RANGE	ACCURACY		
3. Breakers & Surf				
a. Present capabilities				Only visual observations have been made from fixed shore locations.
b. Required capabilities (1) Height	0 to 15 meters	nearest 30 cm	Record length 20 min, 4 observations per day. One to three year record per location.	Height determined from amplitude.
4. Bottom Pressure Fluctuations				
a. Present capabilities (1) Height	Changes in bottom pressure fluctuations over a range from 0.25 cm to 2.50 meters recorded against time.	± 2%	Continuous profile; one 6-hourly observation per 24-hour period; depths 8 to 100 meters.	Height determined from amplitude. Includes gravity and seiche type waves. Equipment is a Solion Infrasonic Hydrophone.
(2) Period		± 2% for time interval between zero crossing.		
b. Required capabilities (1) Height	Changes in bottom pressure fluctuations over a range from 0 to 5.0 meters recorded against time.	± 0.25 mm	Continuous profile; one 6-hourly observation per 24-hour period; depths 8 to 200 meters. One to three year record per location. More frequently for special studies.	In some cases provisions should be made for counting times that threshhold values are exceeded.
(2) Period		± 1% for time interval between zero crossing.		
5. Internal Waves				
a. Present capabilities (1) Height	0 to 60 meters	± 2 meters	Minimum sampling period is 2 min.	Equipment is fast responding suspended thermister beads in a vertical array. Accuracies are dependent on distance between thermister beads. Depth limited by length of vertical array.
b. Required capabilities (1) Height	0 to 100 meters	± 1 meter	Continuous record; sampling intervals down to a few seconds. Depths to 2500 meters. Regular recordings over one to three periods per location.	Fixed towers unusually adaptable to such studies.
6. Sea Level				
a. Present capabilities (1) Height	0 to 20 meters	0.1 foot	Hourly obaervations scaled from continuous record of 17 days over a period of several years at specific locations over the globe.	Operations from fixed stations. Height obtained from tide records.
b. Required capabilities (1) Height	0 to 20 meters	0.01 foot	Continuous records for periods of 17 days and longer.	Records should be scaled for seiche activity.

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

B. PHYSICAL AND CHEMICAL PROPERTIES

VARIABLES	MEASUREMENT		SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATION AND REMARKS
	RANGE	ACCURACY		
1. Temperature				
a. Present capabilities	-2° to 30° C	± .02° C	From Nansen bottles at intervals of 10 meters or less in surface layers and shallow waters to 500 meter intervals at great depths. Approximately 30 samplings in 5000 meter water column requiring 4 hours operating time.	Measurements are by mercurial reversing thermometers.
b. Required capabilities	-2 to 30° C	± .005° C (±.001°C for some special problems)	(a) Require in situ capability to measure continuously at any depth, to raise and lower rapidly to obtain closely spaced vertical profiles. (b) To sample at programmed intervals over a time span of 90 days or less.	(a) Station operation from survey ships, ice islands, towers, or other manned platforms. (b) Synoptic buoy stations or fixed platforms.
2. Salinity				
a. Present capabilities	(a) 1.84 to 41.55 ‰ (b) 32 to 39 ‰ (c) 30 to 40 ‰	± .04 ‰ ± .005 ‰ ± .01 ‰	(a),(b),(c), 300 ml samples of seawater from Nansen bottles at interval of 10 meters or less in surface layers, to 500 meter intervals at great depth. Approximately 30 samples in 5000-meter water column requiring 4 hours of operating time.	(a) By Knudsen method (Generally used when ranges exceed bridge capabilities.) (b) By inductive salinometer (c) Modified Wenner-Smith-Soule salinity bridge. In Situ capabilities not listed in view of limited accuracies.
b. Required capabilities	0 to 44 ‰	± .005 ‰	(a) Require in situ capability to measure continuously at any depth, to raise and lower rapidly to obtain closely spaced vertical profiles. (b) To sample at programmed intervals over a time span of 90 days or less.	(a) Station operation from survey ships, ice-islands, towers, or other manned platforms. (b) Synoptic buoy stations or fixed platforms.
3. Density				
a. Present capabilities	10 to 30 σ_t	± .02 σ_t	Same as Temperature and Salinity.	
b. Required capabilities	-1 to 30 σ_t	± .01 σ_t	Same as Temperature and Salinity.	Same as Temperature and Salinity
4. Dissolved oxygen			Same as Temperature and Salinity.	
a. Present capabilities	0 to 15 ml/L	± 1 %		
b. Required capabilities	0 to 15 ml/L	± ½ %	Same as Temperature and Salinity	Same as Temperature and Salinity
5. pH			Same as Temperature and Salinity	
a. Present capabilities	6.5 to 9.0 pH Units	± .02 pH Units		
b. Required capabilities	6.5 to 9.0 pH Units	± .01 pH Units	Same as Present Capabilities for Temperature and Salinity.	
6. Reactive Phosphate			Same as Temperature and Salinity.	
a. Present capabilities	.08 to 4.0 µg-at PO_4/L	± 1 %		
b. Required capabilities	.08 to 4.0 µg-at PO_4/L	± 1 %	Same as Present Capabilities for Temperature and Salinity.	
7. Total Phosphate				Present method inadequate and considered a safety hazard.
a. Present capability				
b. Required capabilities	.08 to 7.0 µg-at PO_4/L	± 1 %	Same as Present Capabilities for Temperature and Salinity.	Require a quick safe method of laboratory and shipboard analysis.
8. Reactive Silicate			Same as Temperature and Salinity.	
a. Present capabilities	0 to 140.0 µg-at Si/L	± 1 %		
b. Required capabilities	0 to 140.0 µg-at Si/L	± 1 %	Same as Present Capabilities for Temperature and Salinity.	

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

B. PHYSICAL AND CHEMICAL PROPERTIES (CONT'D)

VARIABLES	MEASUREMENT		SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
	RANGE	ACCURACY		
9. Nitrate				
a. Present capabilities	.3 to 45.0 μg-at NO_3/L	± 1 %	Same as Temperature and Salinity.	Must be frozen and analysed ashore.
b. Required capabilities	.3 to 45.0 μg-at NO_3/L	± 1 %	Same as Present Capabilities for Temperature and Salinity.	Shipboard method of analysis desired.
10. Nitrite				
a. Present capabilities	.01 to 2.5 μg-at NO_2/L	± 1 %	Same as Temperature and Salinity.	
b. Required capabilities	.01 to 2.5 μg-at NO_2/L	± 1 %	Same as Present Capabilities for Temperature and Salinity	
11. Magnesium Sulphate				None at present.
a. Present capabilities				
b. Required capabilities	0 to 4 %	± .01 %	Same as Present Capabilities for Temperature and Salinity.	Shipboard method of analysis desired.
12. Background Gamma Radiation				
a. Present apabilities			One observation per hour at mixed layer, below mixed layer, and in deep water. Frequency is seasonal in and below mixed layer, annual in deep water, and continuous over two week period in the pychnocline.	Accuracy of determination is dependent upon activity level and counting time. Count rate per unit energy band is based on background. Background time series will be conducted at depth of seasonal pychnocline for a two week period.
(1) Radioisotope Energy	0 to 3 Mev	± 2 % of actual range		
(2) Cosmic Ray Energy	7 to 100 Mev	± 2 % of actual range		
(3) Radioisotope Count	0 to 10^3 counts per hour per 10 ev	± 1 % to 5 %		
b. Required capabilities			One observation per hour at mixed layer, below mixed layer, and in deep water. Frequency is seasonal in and below mixed layer, annual in deep water, and continuous over two week period in the pychnocline.	Additional detector of larger size and spectrometer are desired.
(1) Radioisotope Energy	0 to 3 Mev	± 2 % of actual range		
(2) Cosmic Ray Energy	7 to 100 Mev	± 2 % of actual range		
(3) Radioisotope Count	0 to 10^3 counts per hour per 10 ev	± 1 % to 5 %		
13. Tracer Gamma Radiation				
a. Present capabilities			One observation per 10 sec at depth of injection with suceeding observations dependent upon tracer movement. To be conducted as rapidly as possible.	Accuracy of determination is dependent upon activity level and counting time. Count rate is a function of injected tracer, activity of injected tracer, and background level.
(1) Energy	0 to 3 Mev	± 2 % of actual range		
(2) Count	0 to 10^6 counts per hour per10 ev	± 10 % of count		
b. Required capabilities			One observation per 10 sec at depth of injection with succeeding observations dependent upon tracer movement. To be conducted as rapidly as possible.	Additional detector requirements of larger size, contamination free, and spectrometer characteristics are desired.
(1) Energy	0 to 3 Mev	± 2 % of actual range		
(2) Count	0 to 10^6 counts per hour per 10 ev	± 10 % of count		

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

C. SEA ICE FEATURES AND PROPERTIES

VARIABLES	MEASUREMENT		SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
	RANGE	ACCURACY		
1. Sea Ice Features a. Concentration (1) Present capabilities	0 to 100%	± 2.5 % if ice concentration is ≤2/10 or >8/10 coverage. ± 10% if ice concentration is ≥2/10 to≤ 8/10 coverage.	Presently, data are primarily obtained through sampling areas throughout the entire Arctic Basin by NAVOCEANO Proj Birds Eye flights in 10 of the 12 months each year. Regular visual observations covering areas of approximately 16 km^2 are made each 55 km. Also continuous data are obtained concerning water openings and ice pressure ridges.	Present data are obtained largely by visual approximation; thus considerable human inexactitude and error is inherent. Although airborne side-looking radar, infrared scanners, and other airborne remote sensing equipments are being employed on a sporadic, opportunity basis, these equipments are experimental; considerable development and interpretational techniques are required.
(2) Required capabilities	0 to 100%	± 2.5 % of total concentration.	Sampling periodic with maximum interval of one month. Shorter interval would permit more effective analyses. Remote sensing systems would appear to provide most feasible mode of data collection for listed sea ice variables. Desire maximum area coverage commensurate with resolution requirements; ideally, synoptic coverage of entire Arctic Basin and marginal seas. Continuous recording of data desired during periods of sampling.	In order to achieve the sampling requirements, an all weather, day-night sensing capability is necessary because in the Arctic Basin heavy cloud incidence and periods of extended darkness are characteristic. Sea ice features listed are extremely variable in time and space owing, primarily, to the continual motion of the pack ice. Frequent recording of this ephemeral data is desired for purpose of ice atlas presentation as well as for relating these variables to the causal environmental factors.
b. Water Openings (1) Present capabilities (a) Visual (1) Length (2) Width	To horizon 1 meter to 24 km	Commensurate with resolution	Same as 1.a.(1)	Subject to human error. Orientation of water openings presently determined as to quadrants.
(b) Remote Sensing Systems	> 0.3 meters	5 to 15%	Sporadic time-space samplings over periods ranging from minutes to days have been accomplished from aircraft, satellites, and submarine platforms on an opportunity basis.	These types of equipments have been used on an experimental basis with sea ice. Further interpretational development is required to ascertain maximum utilization.
(2) Required capabilities (a) Length	As practicable owing to extended nature.	0.3 to 300 meter resolution, dependent on mode and areal size of samplings (180 meters resolution acceptable with extremely large area sample; i.e. satellite imagery) Measurement error commensurate with resolution. Orientation error ± 10°	Same as 1.a.(2)	A capability to detect and distinguish melt pools (Range 1 - several hundred meters in width) from regular water openings is desirable.
(b) Width	0.3 meter to 24km			
(c) Orientation	001° to 360°			
c. Development Stage Age Thickness (1) Present capabilities	0 to 5 meters	Extremely poor	Same as Regional Features	Areal density of sea ice less than 30 Or 40 cm probably can be detected using airborne side-looking radar owing to its normally relatively smooth surface. However, this equipment is still experimental in sea ice studies. Infrared and passive microwave probably hold greater potential in thickness determinations.
(2) Required capabilities	0 to 5 meters	± 5% error	Same as 1.a.(2)	Horizontal distribution by per ent of categorical sea ice thicknesses is desirable. Especial interest concerns the distribution in time and space of sea ice less than 30 cm thick

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

C. SEA ICE FEATURES AND PROPERTIES (CONT'D)

VARIABLES	MEASUREMENT		SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
	RANGE	ACCURACY		
d. Thickness			Same as 1.a.(1)	Present techniques are often unreliable and time consuming. The top-side fathometer is still experimental. Pressure ice draft measured from submarines using top-side fathometers. Accuracy of draft measurements is based on under-ice submarine data collected spasmodically over the past 6 years.
(1) Present capabilities				
Level ice	0 to 5 meters	Unreliable		
Pressure ice Height	0 to 10 meters	Unreliable		
Draft	0 to 45 meters	± 10%		
(2) Required capabilities			Same as 1.a.(2)	Pressure ridges may extend upward to 10 meters above the water level and downward to 45 meters below the water level. A *capability to establish height-draft ratio* is desired; also ratio of overice ridge base to underice ridge base.
Level Ice	0 to 5 meters	Negligible error		
Pressure Ice Height	0 to 10 meters	Negligible error		
Draft	0 to 45 meters	± 10%		
e. Topography Surface Constructions			Same as 1.a.(1)	Determinations from photography are extremely time consuming. Vertical range may reach 15 meters in shoal waters; areal distribution of pressure ice may approach 100% in shoal waters.
(1) Present capabilities				
Vertical	0 to 10 meters	Visual observation extremely unreliable.		
Areal	0 to 55% pressure ice	Visual photography less than 10% error		
(2) Required capabilities			Same as 1.a.(2)	Frequency and distribution of pressure ice by categorical heights is required Especial interest concerns 1/3 highest ridges i.e. the significant height and areal density of such ridges. Also a capability for distinction between ice and snow topography is very desirable.
Vertical	0 to 10 meters	± 10%		
Areal	Extremely *extensive* (0 to 55% pressure ice)	± 10%		
f. Floes			Same as 1.a.(1)	Same as Regional Coverage
(1) Present capabilities				
(a) Width	≥3 km	unreliable		
(2) Required capabilities			Same as 1.a.(2)	Capability to resolve the minimum size may be dependent as contingent features as well as properties of the floe. The minimum range stated could be applied to optimum conditions for detection.
(a) Width	≥3 km	± 10%		
g. Recent Fracture Patterns			Same as 1.a.(1)	Present data collection concerning frequency and orientation of fractures (water openings) is inadequate owing to confined area viewed (visually) as well as unreliability of human observations. The capability exists using side-looking radar data, but at present is only experimental on an opportunity basis.
(1) Present capabilities				
(a) Area	6 to 8 km	Unreliable		
(2) Required capabilities			Same as 1.a.(2)	This feature pertains to the distribution of water openings (and recent pressure ridges) and their orientations with respect to north and to each other at a given time. It seems likely that the extent and duration of fracture systems is variable depending on the strength and duration of the forces responsible.
(a) Area	Extremely extensive	± 10%		
(b) Orientation	001° to 360°	± 10%		

TABLE OF
PROPOSED OCEANOGRAPHIC MEASUREMENT
REQUIREMENTS

C. SEA ICE FEATURES AND PROPERTIES (CONT'D)

VARIABLES	MEASUREMENT RANGE	MEASUREMENT ACCURACY	SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
h. Motion			On an opportunity basis.	Speed and direction determined from long term drifting ice station motion. Present techniques for determining absolute and relative ice motion are entirely inadequate for the purposes required.
(1) Present capabilities				
(a) Speed	0 to 75cm/sec	Very unreliable		
(b) Direction	001° to 360°	Very unreliable		
(2) Required capabilities			Same as I.e.(2)	Telemetering automatic weather stations required to furnish micrometeorological data, current profile data and ice motion data simultaneously. Wind profile data needed to 10 meters above ice. Data includes speed and direction. Also relative motions between discrete areas in the pack ice are desirable.
(a) Speed	0 to 75cm/sec	± 8%		
(b) Direction	001° to 360°	± 10°		
i. Icebergs			On an opportunity basis.	Virtually no data available concerning drafts of icebergs in their source region. No special surveys have been conducted recently. Altimeter estimates of height have been made. This method is unreliable owing to impracticability.
(1) Present capabilities				
(a) Height	<120 meters	unreliable		
(2) Required capabilities			With development of a technique for determining iceberg dimensions, special surveys could be conducted for investigating sizes, etc. (Similar to INTLICEPAT surveys of 1948-49.	Special surveys for icebergs should cover complete source region unlike sampling concept of Birds Eye for Sea Ice study.
(a) Height	<120 meters	± 10%		
(b) Draft	0 to 300 meters	± 10%		
(c) Areal coverage	>60 meters^2	± 10%		
2. Stress Fields				
a. Present capabilities	Unknown	Not determined	Sporadic samplings to date have been made using the NAVOCEANO prototype ice pressure sensor which has a 0 to 280 kg/cm^2 range.	Initial results indicate the stresses in the pack ice to be much less than 280 kg/cm^2. Accordingly, sensor modifications are planned.
b. Required capabilities	Unknown	To be determined	Continuous sampling required using later generation NAVOCEANO pressure sensors or other similar purpose instruments. Locate these instruments over a wide area, (several hundred square miles), and operate simultaneously.	Operating intervals, duration, etc. will be more determinable after amassing initial data which reveal more closely the relations of ice stress and atmosphere pressure along with periodicities.
3. Mechanical Properties				
a. Strength				
(1) Present capabilities	0 to 280 kg/cm	± 1 kg/cm	Present data taken only as part of sporadic experiments in the Arctic.	Measurements include compressive, shear, and flexural strength.
(2) Required capabilities	0 to 280 kg/cm	± 1 kg/cm	Require capability to measure the breaking strength of sea ice of various types and thicknesses at regular intervals (weekly or monthly) throughout the ice season.	Since strength depends on salinity, temperature, porosity of ice, means of simultaneous measurement of these elements within the following ranges should be considered: Temperature: 0 to -50°C Salinity: 0 to 15‰ Porosity: 0 to 50%/cm^3 (within accuracy of ± 1%)

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

D. OCEANOGRAPHIC ACOUSTIC PROPERTIES

VARIABLES	MEASUREMENT RANGE	MEASUREMENT ACCURACY	SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
1. In Sea Water				
a. Sound Speed				
(1) Present Capability	1400-1700 m /sec	±0.3 m /sec from equation ±1.0 m /sec from velocimeter	Readout at 3 meter intervals at 60 m/min. descent by velocimeter From Nansen casts and equation, approximately 35 samplings in 6,000 meter water column, requires 4 hours.	Limited to 6,000 meters or less.
(2) Required Capability	1400-1700 m /sec	±0.03 m /sec	Rapid, continuous readout to any depth. In addition, must sample at programmed intervals over a time span 3 months or less. Record should permit readout of data.	Operation from survey ships, buoys, towers, and ice islands.
b. Transmission Loss				
(1) Absorption			Unspecified at present.	Dependent on frequency temperature, salinity and pressure.
(a) Present Capability	100 cps to 100 kc	Uncertain		
(b) Required Capability	100 cps to 100 kc	±0.01 db/km	Unspecified at present.	Dependent on frequency temperature salinity, pressure, and specific chemical constituents.
(2) Reflection from sea surface			Experimental measurements at various spacings, angle of incidence, and under various sea states.	Insufficient number of observations.
(a) Present Capability	1-kc to 100 kc at sea states 0 to 6	±1.0 db		
(b) Required Capability	100 cps to 100 kc at sea states 0 to 6	±1. 0 db	Sufficient observations to develop and prove relationship to other variables. Continuous samples at single or multiple depths.	Frequency and wave height dependent. Interference by electrical, ship, and hydrophone surging and cable flutter.
c. Ambient Noise				
(1) Present Capability	100 cps to 50 kc	±5 cps ±3 db		
(2) Required Capability	10 cps to 50 kc	±1 cps ±1 db	Continuous samples at single or multiple depths.	Eliminate interference problems.
d. Acoustic Paths				
(1) Present Capability	Compatible with existing weapons systems.	Sufficient to provide fire control data for existing long range ASW weapons.	Surface to bottom over various time periods depending on area and application.	Present day equipment too slow, and too massive.
(2) Required Capability	Compatible with future weapons systems.	Sufficient to provide fire control data for future long range ASW weapons.	Surface to bottom over various time periods depending on area and application.	Shipboard acoustic environmental effects system. Visual display of sound field and intensity.
2. In Sea Floor				
a. Sound Speed				
(1) Present Capabilities			Single observations at selected locations.	Limited to core samples in laboratory.
(a) Laboratory Measurements	1400-8000 m /sec	±10 m/sec		
(b) In Situ	1400-8000 m/sec	±100 m/sec		Limited to seismic methods.
(2) Required Capabilities			Single observations at selected locations.	
(a) Laboratory Measurements	1400-8000 m/sec	±1 m/sec		
(b) In Situ	1400-8000 m/sec	±1 m/sec (Probes) ±10 m/sec (Seismic)	Single observations at selected locations.	Development of probes to be used in situ.
b. Transmission Loss				
(1) Absorption			Single observations for varying bottom sediment conditions.	Function of frequency and sediment conditions. Data limited to 20 kc and greater.
(a) Present Capabilities	20 kc to 1 megacycle	Inadequate		
(b) Required Capabilities	50 cps to 10 kc	±0.1 db/m	Observations for varying bottom sediment conditions.	Derive relationship between frequency and physical properties of bottom sediments.
(2) Bottom Reflection			Single observations at selected locations.	Insufficient data at frequencies of interest.
(a) Present Capabilities	50 cps to 30 kc	± 2 db		
(b) Required Capabilities	50 cps to 30 kc	± 1 db	Sufficient observations to establish bottom loss vs. area.	Establish bottom loss vs.bottom types for frequencies of interest.

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

E. ELECTROMAGNETIC PROPAGATION (INCLUDES LIGHT, RADIO, HEAT)

VARIABLES	MEASUREMENT		SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
	RANGE	ACCURACY		
1. In Sea Water a. Irradiance (1) Present Capabilities	10^{-5} to 10^{4} lumens 8000 Å to 3000Å	± 3%	Not used routinely. No set procedure.	Equipment is very delicate and difficult to use. Alignment is upset easily, calibration is extremely cumbersome, and electronics are unstable.
(2) Required Capabilities	10^{-6} to 10^{4} lumens 8000 Å to 3000 Å	< 3% λ variable down to ±10Å	Rapid continuous readout to 200 meters. In addition, must sample at programmed intervals over a time span of 3 months. Record should print data readout in digital form.	Operation from survey ship, buoys, towers, ice islands, etc. Equipment must be extremely rugged.
b. Beam Attenuation (1) Present Capabilities	0% to 100% 8000 Å to 3000 Å	±2% in turbid water ±0.2% in clear water	Not used routinely. No set procedure.	Equipment is very delicate and difficult to use. Alignment is upset easily, calibration is extremely cumbersome, and electronics are unstable.
(2) Required Capabilities	0% to 100% 8000 Å to 3000 Å	<2% in turbid water <0.2% in clear water λ variable down to ±10Å	Rapid continuous readout to any depth. In addition, must sample at programmed intervals over a time span of 3 months. Record should print data readout in digital form.	Operation from survey ships, buoys, towers, ice islands, etc. Equipment must be extremely rugged.
2. Above Air-Sea Interface a. Solar and Terrestrial Radiation Flux (1) Present Capabilities	0 to 2 gm cal/cm²/min	± 0.005 gm cal/cm²/min	Duration of observations generally limited by length of cruises.	Paucity of accurate data exist owing to nonstandard observation techniques and equipment. Accuracy, limited to stable platforms, may be less from ships
(2) Required Capabilities	0 to 2 gm cal/cm²/min	± 0.005 gm cal/cm²/min	Continuous day and night observations for climatological studies. Three year record required. Shorter observation periods for albedo studies.	Observations from survey ships, Ice Islands, Towers, etc. Correlative observations of cloud amount and type, and sea state and temperature are vital.

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT
REQUIREMENTS

F. SEA FLOOR AND SUB-BOTTOM STRATA

VARIABLES	MEASUREMENT		SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
	RANGE	ACCURACY		
1. Submarine Topography a. Present Capabilities	0 to 11,000 Meters	Timing accuracy of PDR or PGR is one part in 3000. Readout accuracy is ± 4 meters. Cone width creates greater inaccuracies along slope.	Continuous recorded profile with return recorded at maximum rate of once every second, minimum of once every 12 seconds.	All readout and timing done by PDR or PGR. Only transmitter/receiver section of UQN is used. Inaccuracies in system due mainly to use of 60° sound cone and varying sound speed in water.
b. Required Capabilities	0 to 11,000 Meters	±0.03% of total depth.	Continuous recorded profile with digital readout every 2 seconds.	Future requirements set forth in Ship-board Survey System. Contract already let to furnish this.
2. Micro-Bathymetry a. Present Capabilities	0 to 2000 Meters	± 4 meters to 2000 meter depth.	Continuous recorded profile with recorded return at maximum rate of once every second, minimum of once every 12 seconds.	Limited to 6° cone due to large size and power requirements of narrow beam transducers. Limited to 2000 meter depth due to high frequencies used. Lower frequencies require larger transducers to achieve narrow beam unless crossed fan array is utilized.
b. Required Capabilities	0 to 5500 Meters	± 0.03% of total depth over any bottom slope.	Continuous recorded profile with digital readout every 2 seconds or as a function of depth.	1° sound cone with use of crossed fan of transducers on hull is considered.
3. Bottom Composition a. Present Capabilities	Very soft to very hard, although sands are difficult to core.	Disturbed and in some instances the samples are not representative of the interval sampled.	The amount or length of sample required can be obtained with present techniques, with sample disturbance and with difficulty in sampling sands.	Present capabilities generally are suitable for geological studies but not for engineering investigations. The following tools are available: Gravity, piston, and vibracorers, various types of grabs and dredges.
b. Required Capabilities	Very hard to very soft sediments (rock to ooze)	Undisturbed representative sample	Undisturbed cores (3 to 12 meters) and bottom photographs at spacings dictated by variability of sediments. Sub sampling at representative intervals in the core.	When the bottom is too hard to penetrate, other sampling devices are required such as dredges or small rotary drills Cored samples must be undisturbed for use in engineering tests about 30 meters in length.
4. Engineering Properties a. Present Capabilities			Present capabilities allow the collection of the required numbers and lengths of cored samples, but these are generally disturbed samples.	Bulk density and water content can be measured in situ on land and in shallow water (0 to 120 meters) to accuracies of ± 2% with nuclear devices, shear strength is measured in place by means of a vane apparatus on land. Penetrometers or vane devices may be suitable for strength measurements on the sea floor. The relationship of laboratory to in situ values is questionable.
(1) water content	10% to 450% (dry wt.)	± 1%		
(2) bulk density	1.05 to 2.50 gm/cm^3	± 0.01gm/cm^3		
(3) shear strength	7 to 700 gm/cm^2	± 7 gm/cm^2		
b. Required Capabilities			Undisturbed cores (3 to 12 meters) and bottom photographs at spacings dictated by variability of sediments. Sub sampling at representative intervals in the core.	In situ measurements of these parameters is required in water depths up to 6,000 meters and 10 meters into the bottom sediments, where possible. These capabilities presently are not available.
(1) water content	10% to 450 % (dry wt)	± 1%		
(2) bulk density	1.05 to 2.50gm/cm^3	± 0.01 gm/cm^3		
(3) shear strength	7 to 700 gm/cm^2	± 7 gm/cm^2		

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

F. SEA FLOOR AND SUB-BOTTOM STRATA (CONT'D)

VARIABLES	MEASUREMENT		SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
	RANGE	ACCURACY		
5. Chemical Properties				
a. Present Capabilities			Present capabilities allow the collection of the required numbers and lengths of cored samples, but these generally are disturbed samples.	No in-situ capabilities exist at this time. Only laboratory techniques are available.
(1) Organic carbon	0 to 100 %	± 1%		
(2) Chemical composition	0 to 100 %	± 2.0%		
(3) pH	6.0 to 10.0	± 0.1		
(4) Eh	+ 75 to-130 mv	± 0.1 mv		
b. Required Capabilities			Undisturbed cores (3 to 12 meters) and bottom photographs *at spacings dictated by variability of sediments.*	Improvements are needed in the form of an in-situ capability.
(1) Organic carbon	0 to 100 %	± 1%		
(2) Chemical composition	0 to 100 %	± 2.0%		
(3) pH	6.0 to 10.0	± 0.1		
(4) Eh	+ 75 to - 130 mv	± 0.10 mv		
6. Geothermal Measurements			Three to four temperature *measurements at various* depths in the bottom to depths of 12 meters. In water depths to 6,000 meters.	Present techniques require observation times of 10 to 25 minutes per station.
a. Present Capabilities	0° to 5° C	± 0.005° C		
b. Required Capabilities	0° to 5° C	± 0.001° C	Temperature measurements at three or four varing depths (3 to 15 meters) within the sea floor with observation times of two to three minutes. In water depths to 10,000 meters.	Improvements are needed in the recording techniques as well as improving the depth capabilities of the thermistors.

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

G. MARINE ORGANISMS

VARIABLES	MEASUREMENT		SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
	RANGE	ACCURACY		
1. Volume Scattering Coefficient			Coefficients must be computed from individual scattering intensity measurements.	Lacks continuous determination capability.
a. Existing Capabilities				
(1) Frequency	2 to 350 kc			
(2) Intensity	0 to-100 db re 1 dyne/cm^2	± 1 db		
b. Required Capabilities			Require capability to determine (measure and compute) continuously for at least 24 hours from 0 to 1000 meter depth at selected sites and along selected tracks; record should provide automatic readout of coefficients.	
(1) Frequency	2 to 350 kc			
(2) Intensity	0 to-100 db re 1 dyne/cm^2	± 1 db		
2. Target Strength of Individual Scatterers			Measurements and concomitant identification rarely made.	Few measurements and identifications have been made.
a. Existing Capabilities				
(1) Frequency	1 to 25 kc			
(2) Intensity	+ 25 to - 25 db re 1 dyne/cm^2	± 1 db		
b. Required Capabilities			Require measurement of target strength and identification of all species capable of interfering with sonar operation from 0-500 meter depth whenever biological targets occur.	Identification usually is impossible when organisms can't be seen.
(1) Frequency	1 to 25 kc			
(2) Intensity	+ 25 to - 25 db re 1 dyne/cm^2	± 1 db		
3. Plankton and Nekton Sampling			Not carried on with sufficient frequency to identify.	Depth and temperature determinations of net and water at net depth, and measurement of amount of water sampled not sufficiently accurate. Several systems for measuring these factors being designed or tested.
a. Existing Capabilities				
(1) Depth	0 to 2,000 meters	± 25 meters		
(2) Size	0.5 mm to 1 meter			
(3) Volume	Hundreds to millions of liters	Less than required for 1 meter nets; no capability for large trawls		
b. Required Capabilities			Continuous sampling for periods up to 3 hours in depths to 2000 meters at selected intervals and in selected sites, with on-deck read out of depth and temp., accurate opening and closing devices, and/flow meters.	Depth-temperature monitoring system(± 1 meter and ±0.1° C. accuracy) with on-deck read out for attachment to nets and trawls; various nets and collecting devices with demand opening and closing systems.
(1) Depth	0 to 2,000 meters	± 1 meter		
(2) Size	0.5 mm to 1 meter			
(3) Volume	Hundreds to millions of liters	± 1 L/min for 1 meter nets ± 1% of strained volume for large, fish trawls.		

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

G. MARINE ORGANISMS (CONT'D)

VARIABLES	MEASUREMENT		SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
	RANGE	ACCURACY		
4. Fouling Accumulation			Various harbor areas in the U.S. and possessions. Monthly, bi-monthly, yearly, and eighteen month period sampling intervals.	No instrumentation now exists. Present capability consists of fouling plates placed in harbor approaches, removed and photographed on a monthly or bi-monthly basis. Dry weight measurements obtained.
a. Existing Capabilities	15 gm to 20 kg. for 4.5 dm^2 of test surface	± 1gm		
b. Required Capabilities	15 gm to 20 kg for 4.5 dm^2 of test surface	± 1 gm	Require capability to measure automatically fouling accumulation weekly, with provision for continuous measurement and observation for one-month periods over a span of one year at any depth between 10 and 2000 meters at selected sites. Record should permit automatic read out of data and include photographic or TV coverage.	Fouling factors: weight, thickness, gross species composition.
5. Marine Animal Sounds				Several institutions have developed systems for recording and analyzing these sounds; ONR is funding a system for simultaneous recording of sounds and TV viewing of sound producers; Portability and automatic analysis capabilities do not exist.
a. Existing Capabilities				
(1) Frequency	20 cps to 200 kc	± 1cps to ± 1 kc		
(2) Intensity	-60 db to + 60 db re 1 dyne/cm^2	± 1 db		
b. Required Capabilities			Require a portable system for analyzing marine animal sounds and identifying sound producers; capability of continuous recording for periods to 24 hours and automatic analysis for selected periods over a span of one year from surface to 500 meters; system should provide read out of frequency and relative intensity and simultaneous photo record.	
(1) Frequency	20 cps to 200 kc	± 1 cps to ± 1 kc		
(2) Intensity	-60 db to 60 db re 1 dyne/cm^2	± 1 db		
6. Bioluminescence				None at present.
a. From above water				
(1) Existing Capabilities				
(2) Required Capabilities		Signal to noise ratio at least 300: 1 at lowest luminescence	Require capability of measuring intensity and wavelength of bioluminescence in water from above water surface aboard ship or plane at selected sites.	To be used initially in conjunction with operation of bioluminescent organism counter. There should be a capability to measure intensity of various organisms over a specified area and from a specified altitude.
(a) Intensity	1 X 10^{-6} to 1_2X 10^4 microwatts/cm^2			
(b) Wave Length	4000 Å to 7000 Å	± 10 Å		
b. In Water		Signal to noise ratio at least 300:1 at lowest luminescence.	Capability of measuring numbers or luminescent organisms of overall intensity per unit volume for same periods.	Depth limited to about 30-40 meters and no towing capability.
(1) Existing Capability				
(a) Intensity	1 X 10^{-6} to 1_2X 10^4 microwatts/cm^2			
(b) Wave Length	4200 Å to 5400 Å	± 10 Å		
(2) Required Capability		Signal to noise ratio at least 300:1 at lowest luminescence.	Require capability of measuring numbers of luminescent organisms or overall intensity per unit volume for 10-minute periods each hour for at least 24 hours and seasonally for one year; also capability for being towed at any depth to 2000 meters; automatic recording of counts or intensity on deck.	Require towing capability. Also a capability for measuring intensity produced by 1 to 200,000 organisms/L over a specified area.
(a) Intensity	1 X 10^{-6} to 1_2X 10^4 microwatts/cm^2			
(b) Wave Length	4000 Å to 7000 Å	± 10 Å		

TABLE OF
PROPOSED OCEANOGRAPHIC MEASUREMENT
REQUIREMENTS

H. GEOMAGNETISM

VARIABLES	MEASUREMENT RANGE	MEASUREMENT ACCURACY	SAMPLING INTERVAL, MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
1. Total Intensity				
a. Present Capabilities			Continuous analog sampling. Sampling rate variable. 5 samples/sec to 1 sample/10 min (digital).	Data are restricted to a zone from 7500 meters to 100 meters above sea level during airborne operations and from ocean surface to near 2500 meters below during slow marine operations. Station monitor data are collected only at selected points located on land for temporal variation measurements.
(1) Airborne	20,000 to 100,000 gammas	± 15 gammas (absolute) ± 1 gamma (relative)		
(2) Marine	20,000 to 100,000 gammas	± 1 gamma (absolute)	Continuous analog variable sampling rate.	
(3) Station Monitors	20,000 to 100,000 gammas	± .02 gamma (absolute)	Continuous analog sampling. 1 sample/sec to 1 sample/3sec (digital).	
b. Required Capabilities	20,000 to 100,000 gammas	±0.01 gamma (absolute)	Continuous analog sampling. Sampling rate variable: 5 samples/ sec to 1 sample/10 min (digital).	During airborne operations from 9000 meters to 100 meters above sea level and ocean surface to near sea bottom for marine operations. Also, during temporal variation operations at selected points located from ocean surface to ocean bottom and on land.
2. Inclination (Dip)				
a. Present Capabilities (1) Airborne	90°N to 90°S	± 6 min. (absolute)	Continuous analog sampling. Sample rate variable: 5 samples/sec to 1 sample/10 min (digital).	No capability for marine or station monitor measurements.
b. Required Capabilities	90°N to 90°S	±1 min. (absolute)	Continuous analog sampling. Sample rate variable: 5 Samples/sec to 1 Sample/10 min (digital).	During underway operations from 9,000 meters altitude to sea level. During temporal variation operations at selected points.
3. Declination (Variation)				
a. Present Capabilities (1) Airborne	180°E to 180°W	±12 min. (absolute)	Continuous analog sampling. Sample rate variable: 5 samples/sec to 1 sample/10 min (digital).	No capability for marine or station monitor measurements.
b. Required Capabilities	180°E to 180°W	± 1 min. (absolute)	Continuous analog sampling. Sample rate variable: 5 samples/sec to 1 sample/10 min (digital).	During underway operations from 9,000 meters altitude to sea level. During temporal variation operations at selected points.
4. Telluric Currents			Continuous analog sampling.	
a. Present Capabilities				
(1) Station ops.	0 to 1 v/km	± 20 μv/km		
(2) Underway ops.	0 to 1 v/km	± 1 mv/km		
b. Required Capabilities			Continuous analog sampling. Surface to bottom observations Sampling rate variable: 5 samples/sec to 1 sample/sec(digital).	
(1) Station ops.	0 to 1 v/km	± 1 μv/km		
(2) Underway ops.	0 to 1 v/km	± 1 mv/km		

TABLE OF

PROPOSED OCEANOGRAPHIC MEASUREMENT REQUIREMENTS

I. GRAVITY

VARIABLES	MEASUREMENT		SAMPLING INTERNAL MODE, SIZE, AND DURATION	LIMITATIONS AND REMARKS
	RANGE	ACCURACY		
1. Broad Ocean Areas				
a. Present Capabilities	977,000 to 984,000 mgals	± 4 mgals	Continuous analog readout with manual inputs and reductution of data. Sampling interval is 4 to 8 kms. Readings averaged over a 4 to 6 minute periods.	Observations effected and limited by sea state. Reliability of data depends to a large extent on sea keeping characteristics of the platform. Navigation and positional accuracy limits accuracy of data.
b. Required Capabilities	977,000 to 984,000 mgals	± 1 mgal	Surface ship gravity meters. Continuous profiles with discreet values plotted every 4 to 8 kms. Observations averaged over 5 minutes. Unique features noted from inspection of records. Analog and/or automatic digital recording modes	Require greater sea keeping capibility and navigational and positional accuracy needs to be improved.
2. Shoreline & Coastal Areas				
a. Present Capabilities	977,000 to 984,000 mgals	± 1 mgal	Only conducted for special projects. Surface ship and bottomed meters utilized. Manual operations. Readings every 2 kms; surface readings averaged over 4 minute period.	Precise navigational control required for both types of operations. Both types of operations limited by sea conditions and type of platform.
b. Required Capabilities	977,000 to 984,000 mgals	± 1 mgal	Surface ship gravity meters operating in conjunction with remote controlled bottomed gravity meters. Survey area extending from coast to 1000 meter curve. Observations to be recorded at intervals of 2 kilometers. Surface ship meters to be operated continuously by recording analog and/or digital. Remote controlled bottom meter to be lowered and raised with winches as on station operations. Meter read manually.	Improved short range precise navigational capabilities required.
3. Coastal Control Network				
a. Present Capabilities	977,000 to 984,000 mgals	± 0.1 mgal	Establishing shore control stations tied to existing national and international control networks. Ovservations to be made as necessary.	Lack of unified international calibration standards and sufficient density of control.
b. Required Capabilities	977,000 to 984,000 mgals	± 0.1 mgal	Continue to establish world gravity networks. Observations to be made as necessary.	Location and accuracy of existing station. Access to station and transportation calibration of meters.
4. Ice Covered Areas				
a. Present Capabilities				None at present.
b. Required Capabilities	977,000 to 984,000 mgals	± 0.2 mgal	Establish stations from hovering helicopter on sea and lake ice and adjacent shores where reaching area by other means is not practable. Underwater type meter lowered and read from helicopter.	Operations limited by support and flying conditions; no unique instrumentation required except capability to operate at extremely low temperatures.
5. Airborne Worldwide Areas				
a. Present Capabilities				None at present.
b. Required Capabilities	975,000 to 986,000 mgals	± 5 mgals	Continuous rapid observational coverage for determining representative average anomilies for 1 degree and small areas.	Precise determination of altitude and altitude changes as well as precise positioning and navigational control required.